# ESTABLISHMENT OF DESIGN STREAMFLOW HYDROGRAPH IN THE ROMPIN RIVER BASIN

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## STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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## ABSTRAK

Lembangan Sungai Rompin salah satu kawasan daerah di Malaysia yang sering terjejas oleh banjir. Terdapat dua jenis banjir yang berlaku di Lembangan Sungai iaitu banjir monsun dan banjir kilat. Sejak masalah banjir dikenakan kesan yang tinggi terhadap ekonomi sosial dan kesejahteraan seperti korban dan harta benda yang rosak. Adalah penting untuk memahami proses hidrologi yang melibatkan lembangan sungai untuk seterusnya mengurangkan isu banjir. Tujuan kajian ini adalah untuk mensimulasikan, menentukur dan mengesahkan modul hidrografi dan membangunkan Curian IDF dan merancang hujan untuk Sungai Rompin. Model hidrologi dalam kajian ini adalah model HEC-HMS. Data hidrologi yang dikumpul untuk 6 stesen hujan dan 2 stesen aliran sungai dari tahun 1990 hingga 2013 digunakan sebagai data masukan untuk proses pengesahan dan ramalan. Corak hujan yang direka untuk stesen-stesen terpilih ditentukan untuk Interval Gelombang Purata (ARI) selama 2 tahun, 5 tahun, 10 tahun, 50 tahun dan 100 tahun berdasarkan Curves Frequency-Frequency-Intensity (IDF) yang dibangunkan. Untuk pemodelan hidrologi, hidrograf Unit Clark dipilih sebagai kaedah transformasi larian hujan untuk kajian ini di mana parameter Tc dan R dianggarkan menurut Prosedur Hidrologi 27 yang dibangunkan oleh Jabatan Pengairan dan Saliran (JPS) Malaysia. Nombor Curve SCS digunakan sebagai kekasaran permukaan, manakala untuk aliran asas dan aliran laluan, bulanan tetap digunakan. Melalui kajian ini, hasil kajian menunjukkan bahawa model HEC-HMS dapat mensimulasikan aliran hidrograph sungai untuk Sungai Rompin semasa musim aliran tinggi. Ramalan pola aliran aliran masa depan untuk seluruh lembangan dibangunkan berdasarkan ARI yang ditetapkan. Hasil kajian ini adalah penting untuk dijadikan alat sokongan membuat keputusan untuk reka bentuk banjir tebatan. Selain itu, ia juga dapat memberikan jumlah air untuk kejadian hujan tertentu yang penting untuk operasi dan pengurusan di Sungai Rompin dan bekalan air banjir.

## ABSTRACT

The Rompin River Basin one of the district area in Malaysia that often affected by flood. There are two types of floods occur in the River Basin namely the monsoon flood and flash flood. Since flood problems imposed high impact on the social economy and well-being such as casualties and properties damaged. It is important to understand the hydrological processes involved river basin to subsequently mitigate the flood issues. The purpose of this study are to simulate, calibrate and validate the hydrographical module and develop the IDF Curve and design rainfall for the Rompin River Basin. Hydrological model in this study was the HEC-HMS model. Hydrological data collected for 6 rainfall stations and 2 streamflow stations from 1990 to 2013 were used as the input data for verification and prediction processes. Designed rainfall patterns for the selected stations were determined for the Average Recurrence Interval (ARI) of 2 years, 5 years, 10 years, 50 years and 100 years based on the developed Intensity-Duration Frequency (IDF) Curves. For the hydrological modelling, Clark Unit hydrograph was selected as the rainfall runoff transformation method for this study in which the parameters Tc and R were estimated according to the Hydrology Procedure 27 developed by the Department of Irrigation and Drainage (DID) Malaysia. The SCS Curve Number is used as the surface roughness, while for the baseflow and lag routing, constant monthly is used. Through this study, the results show that the HEC-HMS model can sufficiently simulate streamflow hydrograph for Rompin River Basin during high flow season. Prediction of future streamflow patterns for the entire basin were developed based on the designated ARI. The outcome of this study are important to serve as decision-making supporting tool for the design of flood mitigation. Besides, it can also provide water volume for a certain rainfall event which is essential for the operational and management in Rompin River Basin water supply and flood control.

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| | |
|---|---|
| A | Catchment Area (kilometre square) |
| S | Weighted Slope of the Main Stream (kilometre) |
| L | Main Stream Length (kilometre) |
| R | Storage Coefficient (hour) |
| Tc | Time of Concentration (hour) |
| $Q_B$ | Base flow ($m^3/s$) |
| i | Average Rainfall Intensity (mm/hr) |
| ARI | Average recurrence interval |
| T | ARI ($0.5 \leq T \leq 12$ month and $2 \leq T \leq 100$ year) |
| d | Storm duration (hours), $0.0833 \leq d \leq 72$ |
| $\lambda$, $\kappa$, $\theta$ and $\eta$ | Fitting constants dependent (Table 2. B1 in MSMA2) |
| y | observed discharge for RMSE calculation |
| $yi$ | simulated discharge for RMSE calculation |
| Obs | Observed Discharge |
| Sim | Simulated Discharge |
| Omean | Mean of Observed Discharge |

## LIST OF ABBREVIATIONS

| | |
|---|---|
| CN | Curve Number |
| DEM 30m | Digital Elevation Model 30m |
| DID | Department of Irrigation and Drainage |
| GIS | Geographic Information System |
| HEC-HMS | Hydrologic Engineering Centre- Hydrologic Modelling System |
| USDA | United Stated Department of Agriculture |
| HP-27 | Hydrological Procedure 27 |
| MSMA2 | Urban Storm Water Management Manual for Malaysia 2 |
| NSE | Nash-Sutcliffe Efficiency |
| RMSE | Root Mean Square Error |
| RRB | Rompin River Basin |
| SCS CN | Soil Conservation Service Curve Number |
| SRTM | Shuttle Radar Topography Mission |
| UH | Unit Hydrograph |
| USACE | United States Army Corps of Engineers |

# CHAPTER 1

# INTRODUCTION

## 1.1 Background

Malaysia is well-known for its tropical humid climate with year-round rainfall which contributes to the high rate of water resources (Tahir,2007). However, at some point or certain event, excessive water flow causing the occurrence of the floods. Pahang is a wet state and abounds with streams, even in gently undulating areas. This encourage agriculture activities at the low lying region. The streams passing through the basins serve as irrigation demands or ponds dug for agricultural activities. Pahang consists of several districts that are active in agriculture. Most of the agriculture irrigation schemes are located within the Rompin and Pekan District.

Rompin District is often effected by flood particularly during the Northeast Monsoon season which occurs between October to March (Suhaila and Jemain,2007). This phenomenon has been proven in the report IADP Rompin-Endau Scheme (Ranhill Consulting Sdn Bhd, 2011). The total flood prone areas in Rompin is reported be about 1100 $km^2$. According to DID flood report, the worst flood event happened in the Rompin District year 2007 where the highest water level was recorded at is 45 m that exceeding the danger level of 35.4m as shown in Table 1.1.

The unpredictable flood event in the Rompin District due to climate change has made it harder to design the hydrologic structure for flood mitigation and other purpose. Hence, Malaysia has produced several procedures and standards to be considered in future flood study such as Hydrological Procedure (HP1) and Urban Storm Water Management Manual for Malaysia (MSMA2). These hydrological procedures were used in this study to develop the IDF Curve and design temporal rainfall pattern. Furthermore,

Hydrological Procedure (HP27) was referred to establish hydrological modelling setup for the simulation of streamflow hydrographs in The Rompin River Basin.

Hydrological modelling required rainfall data as the input which was then transform into runoff subsequently generated the streamflow pattern. The most commonly used hydrological modelling that can be downloaded without charges is the is Hydrologic Engineering Centre – Hydrologic Modelling System (HEC-HMS) for determining runoff process and predicting streamflow patterns (Razi et.al., 2010).

With application of the HEC-HMS hydrologic model, the rainfall-runoff relationship can be obtained by producing a hydrograph (Tassew,2019). By utilising the rainfall and streamflow data collected from the Department of Irrigation and Drainage (DID), a hydrological model was setup to represents the basin's hydrological response to the streamflow pattern in the Rompin River. Despite streamflow pattern, the hydrologic model also provides water volume information which is important when dealing with potential drought or flood (Yusop et.al.,2007).

Table 1.1 : Flood Level in Rompin District (2007) Based on DID Report

| River | Water Level (m) | Warning Level (m) | Danger Level (m) |
|---|---|---|---|
| River. Pukim | 45.00 | 35.20 | 35.40 |
| River. Keratong (Kg. Rekoh) | 27.30 | 29.20 | 29.40 |
| River. Keratong (Bkt. Serok) | 22.98 | 23.70 | 23.90 |
| River. Rompjn (Kg. Kerpai) | 5.10 | 3.00 | 3.20 |
| Jln. Kg. Kurnia | 1.60 | 2.20 | 2.40 |
| River. Rompin (Kg. Gadak) | 14.38 | 10.50 | 10.70 |
| River. Rompin (Kg. Aur) | 19.94 | 16.00 | 16.20 |
| River. Rompin (Jam. Sabak) | 3.32 | 2.20 | 2.40 |

## 1.2 Problem Statement

High precipitation brought by the Northeast Monsoon season to the Rompin River Basin between the month of October to March contributes huge amount of runoff into the river system. As the consequences, overflows and induced flood at river banks,

downstream and lowland areas which further lead to damage of properties and loss of human lives. Thus, flood mitigation study has become essential to seek for better solution in solving the flood issues. In flood study, hydrological information such as rainfall and streamflow data are crucial to estimate the amount of rainfall runoff. However, most of the rivers in Malaysia including the Rompin River Basin have very limited streamflow data that can be used for hydrograph analysis. This limitation consequently leads to the lacking of study flood since the analysis has become complicated when data for reference is insufficient. Additionally, there is very limited available flood study for the Rompin River Basin indicating restricted hydrological scheme module that can be referred to perform predictive simulation of the potential floods. Thus, the flood study in the Rompin River Basin would require an entirely new hydrological modelling setup for the streamflow hydrograph generation.

HEC-HMS hydrological model is the most widely used in conducting flood studies. The hydrological model is able to analyse the streamflow process and determine the rainfall-runoff processes in the Rompin River Basin. The HEC-HMS model includes various hydrologic analysis procedures such as infiltration, unit hydrographs and hydrologic routing. Moreover, for future estimation streamflow, HEC-HMS also includes necessary procedures for continuous simulation.

Considering the unpredictable rainfall pattern in the Rompin River Basin, there is a need to develop IDF Curve and design rainfall for this area and simulate the streamflow discharge for the Rompin River Basin. The MSMA2 and HP1 hydrological guidelines are useful in developing IDF Curve for all selected rainfall stations and design rainfall pattern in Rompin River Basin. For the Rompin District, only 4 readily available IDF Curve presented in MSMA2. Therefore, it is essential to develop IDF Curve for the other rainfall stations that not included in MSMA2.

Either than that, the limited information of flood prediction study in the Rompin River Basin makes it difficult to predict the potential flood in future. Lack of the rainfall pattern and streamflow hydrograph information, the area will be difficult to predict the flood situation in future. Design rainfall pattern is essential to generate the designed streamflow hydrograph that can be used in future flood study and helped policy makers

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